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14. ABSTRACT

A nested case-control study compared cohort members with an incident post-deployment mental health (PDMH) condition (cases, N = 146) with those without a PDMH condition (controls, N = 800) in terms of deployment-related exposures as ascertained using Post-Deployment Health Assessment DD 2796 questionnaire data. Multivariate logistic regression models were used to compute odds ratios. Non-physician career fields, exposure to dead bodies or people killed/wounded, history of a vehicular accident/crash, exposure to sand/dust, exposure to lasers, and use of mission-oriented protective posture (MOPP) overgarments were associated with increased likelihood for a PDMH condition.

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Assessment of Deployment-Related Exposures on Risk of Incident Mental Health Diagnoses Among Air Force Critical Care Providers: Nested Case-Control Study

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KEYWORDS
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ABSTRACT

Objectives: The purpose of this study was to determine the risk of having deployment-related exposure risk factors for incident post-deployment mental health (PDMH) conditions in a defined population of military healthcare professionals working in the deployed critical care environment.

Methods: A nested case-control study compared cohort members with a PDMH condition (cases, $N = 146$) with those without a PDMH condition (controls, $N = 800$) in terms of deployment-related exposures as ascertained using Post-Deployment Health Assessment DD 2796 questionnaire data. Multivariate logistic regression models were used to compute odds ratios.

Results: Non-physician career fields (i.e., nurses and medical technicians), exposure to dead bodies or people killed/wounded, history of a vehicular accident/crash, exposure to sand/dust, exposure to lasers, and use of mission-oriented protective posture (MOPP) overgarments were associated with increased likelihood for a PDMH condition. The infrequent exposures (i.e., vehicular accident/crash, lasers, and MOPP overgarments) were the exposures most strongly associated with subsequent PDHM conditions.

Conclusions: For military healthcare providers returning from the deployed environment, several exposures are useful for predicting those at increased risk for a PDMH condition. However, there are likely many other important risk factors beyond those captured on the DD 2796 questionnaire.

INTRODUCTION

While the wars in Iraq (Operation Iraqi Freedom) and Afghanistan (Operation Enduring Freedom) have had demonstrable adverse psychological impacts on military personnel,[1-3] there has been relatively little information that directly addresses the impact on military healthcare professionals.[4-7] Given this observation, the authors recently completed a study[8] to ascertain whether Critical Care Air Transport Team (CCATT) members were at increased risk for incident post-deployment mental health conditions. They found there was no additional relative risk for psychological effects that could be attributed to the CCATT work environment per se versus exposure to the deployed healthcare environment. It was observed, however, that both the CCATT members and the control group, the latter comprising job-matched U.S. Air Force (USAF) healthcare professionals with at least one deployment but no CCATT experience, had a burden of mental health conditions that was on par with that of the larger population of military personnel serving in combat-specific occupations.

Based on these findings, mental health subject matter experts recommended a follow-on nested case-control study be accomplished using available Post-Deployment Health Assessment (PDHA) DD 2796 questionnaire data to ascertain the risk for occupational/environment exposures in those military healthcare providers with incident post-deployment mental health conditions in comparison to those without such a diagnosis. Thus, the purpose of this study was to determine the risk of having occupational/environmental exposure risk factors (i.e., odds ratios [OR]) for incident post-deployment mental health (PDMH) conditions in a defined population of military healthcare professionals working in the deployed critical care environment.

METHODS

Study Design

This nested case-control study compared self-reported deployment-related exposures in a previously assembled cohort of USAF healthcare professionals who were originally assessed for the outcome of an incident PDMH condition based on review of electronic health record (EHR) data.[8] The cohort was composed of 1208 specialized physicians, critical care nurses, and cardiopulmonary technicians without preexisting mental health conditions and who had at least one deployment during the period 2003-2012.

Selection of Cases and Controls

Eligibility criteria for this study included membership in the original study cohort and availability of at least one completed PDHA DD 2796 questionnaire. Participants were selected as cases if they were classified in the prior study as having an incident PDMH condition, the latter occurring if a participant had a new mental health diagnosis on at least two separate encounters during the post-deployment period. Participants without an incident PDMH condition were by default selected as controls.

Ethics Approval

The study was conducted under a human-use protocol approved by the 711th Human Performance Wing Institutional Review Board and in accordance with Federal and USAF regulations on the protection of human subjects in biomedical and behavioral research.

Exposure Data

The PDHA DD 2796 questionnaire was developed to assess service members' state of health after deployment outside the United States in support of military operations and to assist healthcare providers in identifying members with healthcare needs. It was developed and first distributed in April 2003 and was revised in January 2008 and again in September 2012. The DD 2796 questionnaire is administered to service members by a trained healthcare provider during in-theater medical out-processing or within 30 days after returning to home station.[9] This screening is used, in part, to identify possible deployment-related occupational/environmental exposures. Further information on the PDHA is available at http://www.pdhealth.mil/dcs/dd_form_2796.asp.

DD 2976 questionnaire responses for cases and controls were obtained from the Defense Medical Surveillance System database. Specific responses corresponding to deployment-related occupational/environmental exposures were extracted and linked to the dataset from the prior retrospective prospective study. Since the DD 2796 questionnaire had gone through several revisions, it was necessary to map the questions and responses for specific occupational/environmental exposures within each version of the questionnaire to a common set of corresponding dichotomous exposure variables (Table I). When a participant had more than one DD 2976 questionnaire available, a composite questionnaire was created in which a positive response to an item on any questionnaire was carried over as a positive response on the composite questionnaire.

TABLE I. Mapping of DD 2796 Questionnaire Exposure Items by Version to Dichotomous Exposure Variable

DD 2796 Questionnaire Exposure Items*	Dichotomous Exposure Variable
• Did you see anyone wounded, killed, or dead during this deployment? [N, Y, Y-coalition, Y-enemy, Y-civilian] (2003) • Did you encounter dead bodies or see people killed or wounded during this deployment? [N, Y, Y-enemy, Y-coalition, Y-civilian] (2008) • Did you encounter dead bodies or see people killed or wounded during this deployment? [N, Y] (2012)	• Dead bodies or people killed/wounded
• Were you engaged in direct combat where you discharged your/a weapon? [N, Y, Y-land, Y-sea, Y-air] (2003, 2008) • Did you engage in direct combat where you discharged a weapon? [N, Y] (2012)	• Discharged a weapon
• During this deployment, did you ever feel that you were in great danger of being killed? [N, Y] (2003, 2008) • Did you ever feel like you were in great danger of being killed? [N, Y] (2012)	• Great danger of being killed
• During this deployment, did you experience any of the following events? [Blast or explosion, Vehicular accident/Crash, Fragment wound or bullet wound above your shoulders, Fall, Other event] (2008) • During this deployment, did any of the following events happen to you? [Blast or explosion, Vehicular accident/Crash, Fragment wound or bullet wound (head or neck), Other event] (2012)	• Blast/explosion • Vehicular accident/crash • Fragment/bullet wound (above shoulder) • Fall/other event
• While you were deployed, were you exposed to: environmental pesticides (like area fogging), smoke from oil fire, smoke from burning trash or feces, vehicle or truck exhaust fumes, tent heater smoke, JP8 or other fuels, fog oils (smoke screen), solvers, paints, ionizing radiation, radar/microwaves, lasers, loud noises, excessive vibration, industrial pollution, sand/dust, depleted uranium, other exposures? [No, Sometimes, Often] (2003) • Are you worried about your health because you were exposed to: depleted uranium, excessive vibration, fog oils (smoke screen), industrial pollution, ionizing radiation, JP8 or other fuels, lasers, loud noises, paints, pesticides, radar/microwaves, sand/dust, smoke from burning trash or feces, smoke from oil	• Depleted uranium • Excessive vibration • Fog oils (smoke screens) • Industrial pollution • JP8 or other fuels • Lasers • Loud noises • Paints • Pesticides (environmental) • Radar/microwaves • Sand/dust • Smoke from burning trash or feces • Smoke from oil fire • Smoke from tent heater • Solvents

fire, solvents, tent heater smoke, vehicle or truck exhaust fumes, other exposures to toxic chemicals or materials? [N, Y] (2008) • Are you worried about your health because you believe you were exposed to something in the environment while deployed? [N, Y] (2012) • Healthcare provider then clarifies the deployer's exposure concerns from the following list: depleted uranium, excessive vibration, fog oils (smoke screen), industrial pollution, ionizing radiation, JP8 or other fuels, lasers, loud noises, paints, pesticides, radar/microwaves, sand/dust, smoke from burning trash or feces, smoke from oil fire, solvents, tent heater smoke, vehicle or truck exhaust fumes, other exposures to toxic chemicals or materials.	• Vehicle or truck exhaust fumes • Other exposure to toxic chemicals *(For the 2003 questionnaire, "sometimes" and "often" were reclassified as "yes.")*
• While you were deployed, were you exposed to: DEET insect repellant applied to skin, pesticide-treated uniforms? [N, Y] (2003) • Force Health Protection Measures: Please indicate which of the following items you used during this deployment and how often you used them. • DEET insect repellant applied to skin • Pesticide-treated uniforms [Daily, Most days, Some days, Never, Not available, Not required] (2008)	• DEET insect repellant • Pesticide-treated uniforms *(For the 2008 questionnaire, "daily," "most days," and "some days" were reclassified as "yes;" "never" was reclassified as "no;" and "not available" and "not required" were reclassified as missing data.)*
• How many days did you wear your MOPP overgarments? [free response] (2003) • Force Health Protection Measures: Please indicate which of the following items you used during this deployment and how often you used them. • MOPP overgarments [Daily, Most days, Some days, Never, Not available, Not required] (2008)	• MOPP overgarments *(For the 2003 questionnaire, 0 days was reclassified as "no" and ≥1 was reclassified as "yes." For the 2008 questionnaire, "daily," "most days," and "some days" were reclassified as "yes;" "never" was reclassified as "no;" and "not available" and "not required" were reclassified as missing data.)*
• How many time did you put on your gas mask because of alerts and NOT because of exercises? [free response] (2003) • Force Health Protection Measures: Please indicate which of the following items you used during this deployment and how often you used them. • NBC gas mask [Daily, Most days, Some days, Never, Not available, Not required] (2008)	• Gas mask *(For the 2003 questionnaire, 0 days was reclassified as "no" and ≥1 was reclassified as "yes." For the 2008 questionnaire, "daily," "most days," and "some days" were reclassified as "yes;" "never" was reclassified as "no;" and "not available" and "not required" were reclassified as missing data.)*

• Were you in or did you enter or closely inspect any destroyed military vehicles? [N, Y] (2003) • Did you enter or closely inspect any destroyed military vehicles? [N, Y] (2008) • Were you in a vehicle hit by a depleted uranium (DU) round, inside a destroyed vehicle that contained DU, or closely inspected such a vehicle? [N, Y, don't know] (2012)	• Destroyed military vehicles *(For the 2012 questionnaire, "don't know" was reclassified as missing data.)*
• Do you think you were exposed to any chemical, biological, or radiological warfare agents during this deployment? [N, Y, don't know] (2003, 2008) • Do you think you were exposed to any chemical, biological, or radiological warfare agents during this deployment? [N, Y] (2012)	• Chemical, biological, radiological (CBR) agents *(For the 2003 and 2008 questionnaires, "don't know" was reclassified as missing data)*
• Did you take any of the following medications during this deployment? [Anti-malaria pills] (2003) • Were you told to take medicines to prevent malaria? [N, Y] (2008, 2012)	• Anti-malaria medication

*Brackets contain relevant possible questionnaire responses.

Statistical Analysis

All the statistical analyses were conducted with SAS version 9.3 (SAS Institute, Inc., Cary, NC). Sample characteristics were described by age group (18-29, 30-39, and 40-60), gender, career field (physician, nurse, and technician), service component (active duty, Guard, and Reserve), and total number of deployments (one versus two or more). Associations between categorical variables were assessed using $\chi 2$ tests. Cases were compared to controls in terms of these demographic characteristics, and where differences were observed, subsequent analyses adjusted for these factors. The association of DD 2796 questionnaire items addressing occupational/environmental exposures with risk for incident PDMH conditions was assessed in adjusted multivariate logistic regression models. A *P*-value of 0.05 was considered statistically significant.

RESULTS

Case and Control Groups

There were 1208 participants in the original cohort study, of which 186 and 1022 were classified as cases and controls, respectively. A total of 946 participants (146 cases and 800 controls) met the nested case-control eligibility criterion of availability of one or more DD 2796 questionnaires. There was no difference between cases and controls in the likelihood of a missing DD 2796 questionnaire (OR 1.103; 95% confidence interval [CI]: 0.693, 1.481). There were several statistically significant differences between eligible cases and controls (Table II). Cases differed from controls in the proportional distribution of career field, with cases being predominantly nurses followed by technicians as compared to physicians followed by nurses for controls. Additionally, the proportional distribution of females and those with ≥2 deployments was greater for cases as compared to controls.

TABLE II. Demographic Characteristics of Cases and Controls

Characteristic	Cases (*n* = 146)	Controls (*n* = 800)	*P*-value*
Career Field			
Physician	29 (19.86)	342 (42.75)	
Nurse	66 (45.21)	288 (36.00)	<0.001
Technician	51 (34.93)	170 (21.25)	
Service Component			
Active Duty	120 (82.19)	603 (75.38)	
Air National Guard	12 (8.22)	98 (12.25)	0.194
Air Force Reserve	14 (9.59)	99 (12.38)	
Gender			
Male	75 (51.37)	521 (65.13)	0.002
Female	71 (48.63)	279 (34.88)	
Age (yr)			
18-29	61 (41.78)	312 (39.00)	
30-39	61 (41.78)	353 (44.13)	0.814
40-60	24 (16.44)	135 (16.88)	
Marital Status†			
Married	85 (58.22)	449 (56.55)	
Single	53 (36.30)	301 (37.91)	0.930
Divorced	8 (5.48)	44 (5.54)	
Total Dependents			
0	69 (47.26)	354 (44.25)	
1	23 (15.75)	147 (18.38)	
2	22 (15.07)	126 (15.75)	0.941
3	20 (13.70)	106 (13.25)	
4 or more	12 (8.22)	67 (8.38)	
Total Deployments			
1	77 (52.74)	494 (61.75)	0.041
2 or more	69 (47.26)	306 (38.25)	

*Pearson χ^2 test.
†Missing n=6.

Exposure Analysis

Data were evaluated on the exposures (i.e., potential risk factors) self-reported by participants on the DD 2796 questionnaire. In total, 1490 questionnaires were identified for the 946 participants, or approximately 1.6 questionnaires per person. Of these questionnaires, 711 (48%) were the 2003 version, 775 (52%) were the 2008 version, and 4 (<1%) were the 2012

version. Table III summarizes reported exposures for cases and controls. Statistically significant differences were observed for exposure to dead bodies or people killed/wounded ($P = 0.005$), multiple environmental exposures (depleted uranium [$P = 0.006$], fog oils [$P = 0.018$], industrial pollution [$P = 0.003$], JP8 or other fuels [$P = 0.001$], lasers [$P < 0.001$], sand/dust [$P = 0.001$], solvents [$P = 0.019$], and vehicle or truck exhaust fumes [$P = 0.002$]), and DEET (N,N-Diethyl-meta-toluamide) insect repellent ($P = 0.011$).

TABLE III. Exposure Characteristics of Cases and Controls

Exposure	Cases (n = 146)	Controls (n = 800)	P-value*	Frequency Missing
Dead bodies or people killed/wounded	128 (87.67)	619 (77.38)	0.005	
Discharged a weapon	1 (0.68)	2 (0.25)	0.396†	
Great danger of being killed	38 (26.03)	178 (22.28)	0.321	1
Blast/explosion	7 (8.14)	32 (6.11)	0.475	336
Vehicular accident/crash	3 (3.49)	4 (0.79)	0.062†	336
Fragment/bullet wound (above shoulder)	0 (0.00)	0 (0.00)	--	336
Other event	18 (20.93)	71 (13.55)	0.248	336
Depleted uranium	5 (3.42)	6 (0.75)	0.006	1
Excessive vibration	51 (34.93)	218 (27.25)	0.059	
Fog oils (smoke screen)	9 (6.16)	20 (2.50)	0.018	
Industrial pollution	53 (36.30)	195 (24.38)	0.003	
Ionizing radiation	21 (14.38)	94 (11.75)	0.371	
JP8 or other fuels	51 (34.93)	178 (22.25)	0.001	
Lasers	12 (8.22)	16 (2.00)	<0.001	
Loud noises	92 (63.01)	457 (57.13)	0.185	
Paints	17 (11.64)	67 (8.38)	0.202	
Pesticides (environmental)	20 (13.70)	100 (12.50)	0.689	
Radar/microwaves	26 (17.81)	100 (12.50)	0.083	
Sand/dust	118 (80.82)	533 (66.63)	0.001	
Smoke from burning trash or feces	91 (62.33)	438 (54.75)	0.090	
Smoke from oil fire	28 (19.18)	129 (16.13)	0.362	
Smoke from tent heater	10 (6.85)	50 (6.25)	0.785	
Solvents	19 (13.01)	58 (7.25)	0.019	
Vehicle or truck exhaust fumes	84 (57.53)	351 (43.88)	0.002	
Other exposure to toxic chemicals	18 (12.33)	93 (11.64)	0.812	1
DEET insect repellent	80 (57.97)	335 (46.14)	0.011	82
Pesticide-treated uniforms	90 (65.22)	457 (62.26)	0.510	74
MOPP overgarments	3 (2.16)	3 (0.42)	0.058†	93
Gas mask	3 (2.14)	14 (1.94)	0.748†	86
Destroyed military vehicles	6 (4.11)	28 (3.50)	0.716	
CBR agents	3 (2.24)	6 (0.81)	0.146†	68
Anti-malaria medication	63 (43.75)	349 (44.18)	0.924	12

*Pearson χ^2 unless noted otherwise.
†Fisher's exact test.

Multivariate logistic regression analyses were carried out on the exposure data to identify associations between specific exposures and incident PDMH conditions while accounting for potential covariates. Exposure indicator variables (i.e., binary variables indicating whether an exposure was reported versus the absence of an exposure was reported) and variables corresponding to the demographic characteristics shown in Table I were included in the model, which was fitted using stepwise logistic regression. Only those exposures with a P-value ≤ 0.10 were considered for inclusion in the regression. For those demographic characteristics in which cases differed from controls (i.e., career field, gender, and total deployments), the corresponding variables were forced into the final fitted model. Since the DD 2796 questionnaire was substantially revised between the 2003 versus 2008 and 2012 versions, the analysis was stratified based on questionnaire version (i.e., 2003 versus 2008-2012). It was also observed that there was an unexplained and relatively high frequency of missing data in the 2008 and 2012 versions of the DD 2796 questionnaire for those questions addressing exposures to DEET insect repellant and mission-oriented protective posture (MOPP) overgarments (i.e., chemical protective clothing). Consequently, the analysis was further stratified for the 2008-2012 strata based on inclusion versus exclusion of those exposures in the model.

The results of the stratified multivariate logistic regression analysis (Table IV) revealed one demographic characteristic and several exposures were significantly related to an incident PDMH health condition. In terms of the strata, based on data from the 2003 version of the DD 2796 questionnaire, technicians were twice as likely as physicians, and those exposed to lasers were four times more likely than those non-exposed, to have an incident PDMH condition. Based on the data from the 2008 and 2012 versions of the DD 2796 questionnaire, nurses were approximately 2.5 times as likely as physicians and technicians were 3.5 times more likely as

physicians to have an incident PDMH condition. Regardless of stratification based on inclusion/exclusion of DEET and MOPP overgarment exposures, exposures to a vehicular accident/crash and sand/dust were both associated with an increased likelihood for an incident PDMH condition (5 to 11.5 times more likely for vehicular accident/crash and twice as likely for sand/dust exposures versus those non-exposed). When data for DEET insect repellant and MOPP overgarment exposures were included in the analysis, those reporting a MOPP overgarment exposure were 14 times more likely than those without the exposure to have an incident PDMH condition, although the CI for the estimated OR was wide (2-108). When data for DEET insect repellant and MOPP overgarment exposures were excluded from the analysis, exposure to seeing dead bodies or people killed/wounded was associated with a four times greater likelihood for an incident PDMH condition, and the CI for the estimated OR was substantially narrower than that for MOPP overgarment exposure. It is worth noting the absolute frequency of reported exposures was low for the following exposures that were included in the final fitted models: laser (n = 28), vehicular accident/crash (n = 7), and MOPP overgarments (n = 6).

TABLE IV. Logistic Regression Models of Risk Factors for Incident Post-Deployment Mental Health Conditions

Characteristic/Exposure	2003 (n = 331/334) OR (95% CI)	2008-2012 *(with DEET & MOPP)* (n = 488/612) OR (95% CI)	2008-2012 *(without DEET & MOPP)* (n = 606/612) OR (95% CI)
Career field			
Nurse vs. Physician	2.007 (0.907, 4.441)	2.485 (1.248, 4.947)	2.558 (1.344, 4.867)
Technician vs. Physician	2.914 (1.315, 6.457)	3.406 (1.653, 7.020)	3.543 (1.815, 6.915)
Gender			
Female vs. Male	1.808 (0.978, 3.343)	1.328 (0.768, 2.296)	1.315 (0.794, 2.180)
Total deployments			
2 or more vs. 1	1.354 (0.738, 2.482)	1.550 (0.912, 2.632)	1.439 (0.882, 2.348)
Dead bodies or people killed/wounded			3.537 (1.454, 8.601)
Yes vs. No			
Vehicular accident/crash*			
Yes vs. No		11.516 (1.753, 75.665)	5.191 (1.090, 24.716)
Sand/dust			
Yes vs. No		2.179 (1.149, 4.131)	1.818 (1.027, 3.220)
Lasers			
Yes vs. No	4.717 (1.385, 16.067)		
MOPP overgarments			
Yes vs. No		13.511 (1.691, 107.970)	

*Question not present in 2003 version of questionnaire.

The statistical properties of the final fitted regression model for the 2003 version of the DD 2796 questionnaire were as follows: the Homser-Lemeshow goodness of fit χ^2_6 was 0.809 (P = 0.992), the area under the receiver operating characteristic (AUROC) curve measuring the accuracy of the model predicting the response was 0.672, and Nagelkerke's adjusted R^2 estimating the amount of variance explained by the model was 0.103. The statistical properties of the model for the 2008-2012 version of the DD 2796 questionnaire including the DEET and MOPP overgarment data were as follows: the Homser-Lemeshow goodness of fit χ^2_8 was 8.831 (P = 0.357), the AUROC was 0.690, and Nagelkerke's adjusted R^2 was 0.132. Lastly, the

statistical properties of the model for the 2008-2012 version of the DD 2796 questionnaire excluding the DEET and MOPP overgarment data were as follows: the Homser-Lemeshow goodness of fit χ_7^2 was 3.038 (P = 0.882), the AUROC was 0.714, and Nagelkerke's adjusted R^2 was 0.136.

DISCUSSION

To the best of the authors' knowledge, this study was the first analysis of deployment-related occupational/environmental exposures and the risk for incident PDMH conditions in a cohort of USAF healthcare personnel. Unlike the limited number of studies addressing this issue in military healthcare personnel, this study used actual diagnoses as derived from EHR systems to determine the outcome and archived survey data from the post-deployment medical surveillance system to ascertain exposures. Also, this study was relatively unique compared to similar studies in the literature as it was not cross-sectional in nature—that is, exposure and outcome were not simultaneously established. Accordingly, there is less ambiguity in the temporal relationship between exposure and outcome.

Data analysis indicated non-physician career fields (i.e., nurses and medical technicians), exposure to dead bodies or people killed/wounded, history of a vehicular accident/crash, exposure to sand/dust, exposure to lasers, and use of MOPP overgarments were all associated with increased likelihood for an incident PDMH condition. Of these, the most frequent exposures—that is, career field (n = 354 for nurses and n = 221 for technicians), dead bodies or people killed/wounded (n = 747), and sand/dust (n = 651)—were associated with a relatively modest increased likelihood (≤3.5 times) for an incident PDMH condition. In contrast, the less frequent exposures—that is, vehicular accident/crash (n = 7), lasers (n = 28), and MOPP overgarments (n = 6)—were associated with a greater likelihood (4.7-13.5 times) for an incident PDMH condition. When looking at the global sample, the rare exposures were most frequently

associated with subsequent mental health conditions. A similar pattern was observed by Bouchard and colleagues[10] in an analysis of survey data from a cohort of 1319 Canadian Forces personnel previously deployed to Afghanistan. The public health challenge in this situation is to strike a balance between the frequency and consequences of exposures when planning preventive programs in an environment of constrained resources.

For the demographic factors assessed in this study, there were no observed associations between age, gender, marital status, number of dependents, service component, or number of deployments and the likelihood of an incident PDMH condition. Career field was an identified demographic risk factor, with nurses and technicians having an increased likelihood of an incident PDMH condition as compared to physicians. It is noteworthy that female gender was associated with increased risk for an incident post-deployment mental health condition in the original cohort study,[8] but a similar association was not observed in this nested case-control study when deployment-related exposures were included with gender in the multivariable models.

A review of the relevant literature on these factors, in terms of healthcare professionals with combat-related exposures in both civilian and military settings, was provided by the authors in their discussion of the results of the original cohort study.[8] In summation, this study's finding that gender was not associated with an increased likelihood of an incident PDMH condition was consistent with the results of Ben-Ezra, Palgi, and Essar[11] and Kolkow and colleagues.[7] However, this finding was in contrast to the report of increased risk of female gender shown by Ben-Ezra and colleagues[12] and Gibbons and colleagues.[5] This study's finding that nurses had an increased likelihood of an incident PDMH condition was consistent with the results from Ben-Ezra, Palgi, and Essar,[12] although the magnitude of the association was approximately half of

that reported by them. Similarly, the increased likelihood of an incident PDMH condition in enlisted medical technicians was consistent with that observed by Gibbons and colleagues.[5] Lastly, the lack of observed effects of service component and number of deployments was consistent with findings from a cohort study in the United Kingdom armed forces that specifically examined medical services personnel as a subgroup of interest.[6]

There were few published studies that evaluated the association between deployment-related exposures and mental health outcomes in military healthcare personnel. Kolkow and colleagues[7] conducted a cross-sectional survey of 102 medical staff at a single U.S. Navy hospital to identify demographic and exposure risk factors for post-traumatic stress disorder (PTSD), depression, and mental healthcare utilization among medical personnel who had deployed to a combat zone. Reported direct and perceived threats of personal harm were associated with an increased risk of PTSD (OR: 17.0; 95% CI: 1.9, 156.0 and OR: 8.9; 95% CI: 1.1, 68.7, respectively). Reported frequent exposure to dead or wounded service members and civilians was not associated with either PTSD or depression. Kolkow and colleagues' findings differ from those observed in the present study, where both reported direct and perceived threats of personal harm were not associated with an increased likelihood for an incident PDMH condition, and exposure to dead bodies or people killed/wounded was associated with an increased likelihood for an incident PDMH condition.

Jones and colleagues[6] conducted a cross-sectional analysis of survey data available on 479 medical personnel and 5345 non-medical personnel in the United Kingdom armed forces who deployed to Iraq. They observed medics were more likely to report multiple psychological distresses, and combat-related traumatic experiences did not explain the positive associations with psychological ill health in medics. However, medical traumatic experiences, such as seeing

personnel wounded or killed, giving aid to wounded, and handling bodies, did explain the psychological ill health in medics. Overall, these results are generally consistent with the findings of the present study.

This study's finding of an increased likelihood for an incident PDMH condition given a history of a vehicular accident/crash was consistent with a small body of literature suggesting motor vehicular accidents are significant risk factors for subsequent mental health conditions.[13-15] Mayou and Bryant,[15] in particular, undertook a cohort study of a 1-year sample of 1148 individuals who consecutively went to an emergency department following a road traffic accident to determine psychological outcomes at 3 months and 1 year. Approximately one-third of participants had at least one of four psychological conditions (i.e., PTSD, phobic travel anxiety, general anxiety, or depression) at both 3 months and 1 year post-accident. The small proportion of the cohort with the most serious injuries was twice as likely to suffer PTSD and travel anxiety at 1 year. More noteworthy, the much larger majority with less serious or no injuries also suffered long-term consequences that were largely unrelated to the type of injury.

This study's observation of an increased likelihood for an incident PDMH condition associated with sand and dust exposure was potentially noteworthy given the findings by Prabhakaran and Gunasekar.[16] They performed an in vitro study evaluating the effects of the soluble components of Afghanistan sand on rat dopaminergic neuronal cells. They determined the soluble components of this sand could be toxic to neuronal cells by enhancing reactive oxygen species and impairing mitochondrial function. Gunasekar, quoted in a review in the popular press of his and colleagues' work,[17] observed that dust in sandstorms contains manganese and other metals with known associations with neurotoxicity. Service members caught in sandstorms may potentially inhale "toxic particles," which can be carried to the brain.

This might explain post-deployment complaints about respiratory problems and cognitive function, the latter including lack of focus, problems with short-term memory, and symptoms that overlap with depression and PTSD. The only other study informing this observation was that by Meo and colleagues,[18] who conducted a cross-sectional survey of 517 healthy volunteers who were exposed to a sandstorm in Riyadh, Saudi Arabia. They observed 37.5% of the volunteers reported psychological disturbances among other issues such as respiratory problems and sleep disturbances.

This study's findings on an increased likelihood for an incident PDMH condition with exposure to lasers and MOPP overgarments were without empirical points of comparison in the published literature. In a review article on the impact of chemical protective clothing on performance, Bensel[19] reported negative psychological reactions to chemical protective clothing have been observed during field exercises in which personnel wore the clothing for as little as 1-2 hours. It was noteworthy that the respirator was the item of chemical protective gear chiefly responsible for the negative psychological reactions described by Bensel, but the present study identified an association only with the outer garment and not the mask. An alternative explanation for the observed association was provided by Krueger and Banderet,[20] who suggested the potential for "maladaptive overreactions" caused by overestimation of the dangers of potential chemical agent exposures. A similar hypothesis was adopted for the observed association with exposure to lasers: Mastroianni and Stuck,[21] writing in 1987 about the advent of lasers on the battlefield, discussed the potential for psychological reactions occurring solely due to the employment or possibility of employment of lasers (i.e., perceived threat of blindness).

Study Limitations

Both a strength and weakness of this study was the ascertainment of the outcome event using diagnosis data extracted from EHRs. The data in the EHR yielded validated mental health diagnoses that were not constrained to the diagnoses for which ready survey instruments exist. Additionally, EHR data provided the opportunity to detect cases outside the standard post-deployment medical surveillance period. However, it is well known validated diagnoses represent only visible cases—that is, the iceberg phenomenon, where the number of people with diagnosed disease is a smaller subset of the total number of people with the disease.[22] With regards to the latter, the primary risk to this study was misclassification of cases as controls, which would lead to an underestimation of the strength of association between exposures and incident PDMH conditions. An additional strength of the study was the ascertainment of exposures from archived post-deployment health assessment survey data, thereby minimizing the risk for recall bias.

A weakness of the study was the limited ability of the fitted models to discriminate between cases and controls given the demographic and exposure data. The accuracy of a binary model can be assessed based on the AUROC; an area of 1.0 represents perfect discrimination and an area of 0.5 represents model performance no better than chance. Based on the calculated AUROCs, this study's final statistical models had only marginal to fair performance in correctly identifying most cases and controls. These results were not surprising given the observation by Sareen and colleagues[23] found even in a military sample: most mental health conditions are likely attributable to a wide range of putative risk factors such as genetics, childhood adversity, stressful life events, social supports, and personality.

Another weakness of the study was the a priori presumption that there were potential etiological associations between exposures and outcomes. For example, the limited literature on sand exposure and psychological effects presumes a toxic-mediated mechanism of action. However, it is just as plausible that sand exposure was confounded with situational factors such as living in a perceived foreign environment or being deployed to an austere location. Likewise, the observed associations between infrequent exposures, such as to lasers and MOPP overgarments, and psychological effects may be confounded with the jobs or tasks that drove those exposures rather than the exposures themselves. Unfortunately, it is impossible to explore such potential confounders with the existing archived data. The missing contextual data would only be attainable through interviews, which introduce the associated threat of recall bias.

Suggestions for Future Research

Little is known about the incidence of PDMH conditions for other medical specialties outside those included in the original cohort study. Future research should expand the scope of healthcare career fields considered and ascertain the relative contribution of specialty-unique exposures versus exposure to the deployed healthcare environment in general. In addition, future studies should more directly determine the nature of wartime exposures (patient contact versus combat) to assess the relative contribution of different exposures to the development of PDMH conditions. Lastly, future research should examine the characteristics (i.e., sensitivity, specificity, positive predictive value, and negative predictive value) of the DD 2976 questionnaire as a screening instrument for mental health conditions in a population of military healthcare personnel.

Summary

This nested case-control study evaluated deployment-related occupational/environmental exposures and the likelihood for incident PDMH conditions in a predefined cohort of USAF healthcare personnel. Non-physician career fields (i.e., nurses and medical technicians), exposure to dead bodies or people killed/wounded, history of a vehicular accident/crash, exposure to sand/dust, exposure to lasers, and use of MOPP overgarments were all associated with increased likelihood for an incident PDMH condition.

Relative to the entire cohort, the infrequent exposures (i.e., vehicular accident/crash, lasers, and MOPP overgarments) were the exposures that were most strongly associated with subsequent incident mental health conditions. However, this study's final statistical models suggested the occurrence of incident PDMH conditions was likely attributable to a wider range of risk factors than just the demographic and exposure factors considered.

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